THE UNIVERSITY OF MARYLAND, BALTIMORE COUNTY (UMBC)

Department of Mechanical Engineering

ENME677-Applied Elasticity
Spring 2015

Credits:	**3**
Instructor:	Panos G. Charalambides
Office:	209 & 211 Engineering Building
Tel. No.:	(410) 455-3346

Outline

In this course, the basic concepts of deformation strain and stress are treated as vector and tensor quantities of known mathematical properties. Thus, initially, the tool of indicial notation will be used throughout to effectively reduce the complexity arising from the 3-dimensional nature of the above quantities. The 3D eigenvalue problem will be presented as needed to explore the 3-dimensional nature of the stress and strain tensors. The deformations within the continuum will be derived in terms of a large deformation gradient composed of a deformational and a rotational part. Small strains and deformations will be obtained via a linearization procedure. The physical principle of conservation of mass together with the balance laws of linear and angular momentum will be employed to derive the equations of motion and boundary conditions for the elastic continuum. The elasticity boundary value problem (bvp) will then be formulated in the stress/deformation space through the equations of motion, compatibility, stress-strain relations and boundary conditions. A reduced set of equations will be presented for the plane stress/strain problems in both the Cartesian and Polar coordinates. Methods in solving the boundary value problem and various elasticity solutions will be presented. The second part of the course will focus on solving a broad range of elasticity problems that include polar and spherical symmetry displacement formulations, planar (2D) stress and Airy stress function formulation, 3D torsion and bending, fracture mechanics, non-dimensional methods and if time allows, approximate numerical methods. The extensive use of elasticity in understanding the mechanics of modern composites will be highlighted.

Integrity:
A Value That Endures

ACADEMIC INTEGRITY

"By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. To read the full Student Academic Conduct Policy, consult the UMBC Student Handbook, the Faculty Handbook, or the UMBC policies section of the UMBC Directory." *UMBC Faculty Senate, February 13, 2001.*

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Lectures MW 10:00-11:15 a.m. (ITE239)
Office Hours: MW 4:00-5:00 p.m. and by appointment.

Textbook: Boresi, A.P. & Chong, K.N. Elasticity in Engineering Mechanics, 3rd edition Elsevier Science Publishers Co., Inc., 1987.

Grading Policy Homework 40% Midterm 30% Final Exam 30%

List of books for complementary reading

Elasticity

Sokolnikoff I. S.	Mathematical Linear Theory of Elasticity, 2nd Edition, (McGraw-Hill), 1956.
Timoshenko S. & Goodier J. N.	Linear Theory of Elasticity, 2nd Edition, (McGraw-Hill), 1951.
Love A. E. H.	A Treatise on the Mathematical Linear Theory of Elasticity, 4th Edition, (Cambridge University Press), 1927; (reprinted by Dover), 1944.
Muskhelishvili N. I.	Some Basic Problems of the Mathematical Theory of Elasticity, translated by J. R. M. Radok, (P. Noordhoff Ltd.),1963.
Green A. E. and Zerna W.	Theoretical Elasticity, Clarendon Press-Oxford, 1954.
Gurtin M.E.	The Linear Linear Theory of Elasticity, In Encyclopedia of Physics (ed. S. Flugge) Vol. 6a/2, Springer-Verlag, 1975.
Oden, Ripperger	Mechanics of Elastic Structures, 2nd Ed., McGraw-Hill, 1981.

Continuum Mechanics

Malvern, L. E.	Introduction to the Mechanics of a Continuous Medium (Prentice-Hall), 1969.
Lai, W.M., Rubin, D. And Krempl, E.	Introduction to Continuum Mechanics (Elsevier Ltd., ISBN 978-0-7506-8560-3), 2010.
Ziegler, H.	An Introduction to Thermodynamics, North-Holland, 1977
Fung, Y.C.	Foundations of Solid Mechanics, Prentice-Hall, 1965
Prager, W.	Introduction to Mechanics of Continua, Ginn and Co., 1961; Reprinted by Dover, 1973
Truesdell, C. and Touplin, R.A.	The Classical Field Theories, in Encyclopedia of Physics (ed. S. Flugge) Vol. 3/3, Springer-Verlag, 1960.
Truesdell, C. and Noll	The Non-linear Field Theories of Mechanics in Encyclopedia of Physics (ed. S. Flugge) Vol. 3/3, Springer-Verlag, 1975.

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OUTLINE OF TOPICS

	Reading
Preliminaries (1 week)	Chapter 1
Indicial Notation Basic Vector and Tensor Operations Eigenvalue Problem Green-Gauss (Divergence) Theorem	
Kinematics (1 week)	Chapter 2
General finite deformation of a continuum Infinitesimal deformation Decomposition Compatibility	
Kinetics &Constitutive relations of elasticity (1 1/2 weeks)	Chapters 3 & 4
Various stress measures, Piola-Kirchhoff & Cuachy stress tensors Equations of motion in integral and differential forms Hyper- Hypo elasticity General anisotropic elasticity- Cauchy relation Isotropic linear elasticity	
Work and Energy balance (1 1/2 weeks)	Chapters 3 & 4
Strain energy for elastic materials Basic equations of linear elasticity Principal of virtual work Boundary value problem and uniqueness of solution Reciprocal theorem, etc.	
Plane problems of elastostatics (Cartesian & Polar Coordinates) (5 weeks)	Chaps. 5 & 6
Plane stress Plane strain Airy's stress function and other polynomial stress functions Concentrated line load Punch problems Edge & Skrew dislocations Complex function formulation Asymptotic singular near-tip solution	
Special Topics (Extension, Torsion and Flexure of Beams) (4 weeks)	Chaps 7 & 8
Semi-inverse method Bending of beams by terminal couples Torsion of circular and non-circular sections Prandtl's stress function and membrane analogy Multiply-connected sections Bending of beams by an end load	

OTHER TOPICS IN ELASTICITY

3-Dimensional problems of elastostatics

- Concentrated forces
- Kelvin and Boussinesq problems
- Singular solutions
- St. Venant principle
- Boundary layer theory
- Eshelby's homogeneous strain transformation problems
- General strain transformation problems
- Voltera's theory of dislocations
- Contact problems

Variational Methods in Elasticity

- Variational problems and Euler's equations
- Minimum potential energy principle
- Minimum complementary energy principle
- The Ritz method
- The Galerkin method
- The method of Kantorivich
- The Trefftz method
- Finite element method, etc.

Elastodynamics

- Suddenly introduced line load in an infinite medium
- Lamb's problem
- Various waves in an elastic medium
- Propagation and reflection of waves, etc.

Topics of Research Interest

- Hilbert-Arc problem & Near -tip elasticity for cracks at bimaterial interfaces.
- Elasticity of layered media
- Thermal stresses in composites & electronic packaging
- Elasticity of Porous Media
- Damage mechanics (Self consistent and differential methods)
- Anisotropy & elasticity of composite media
- Non-linear elasticity
- Visco-elastic response
- Elastica problem

Weekly Time Schedule

Time	Monday	Tuesday	Wednesday	Thursday	Friday
8:00-9:00					
9:00-10:00					
10:00-11:00					
11:00-12:00					
12:00-1:00					
1:00-2:00					
2:00-3:00					
3:00-4:00					
4:00-5:00					
5:00-6:00					

Please indicate conflict hours on the above time schedule and return to me as soon as possible for alternative meeting arrangements.

Student Name________________________________Date____________